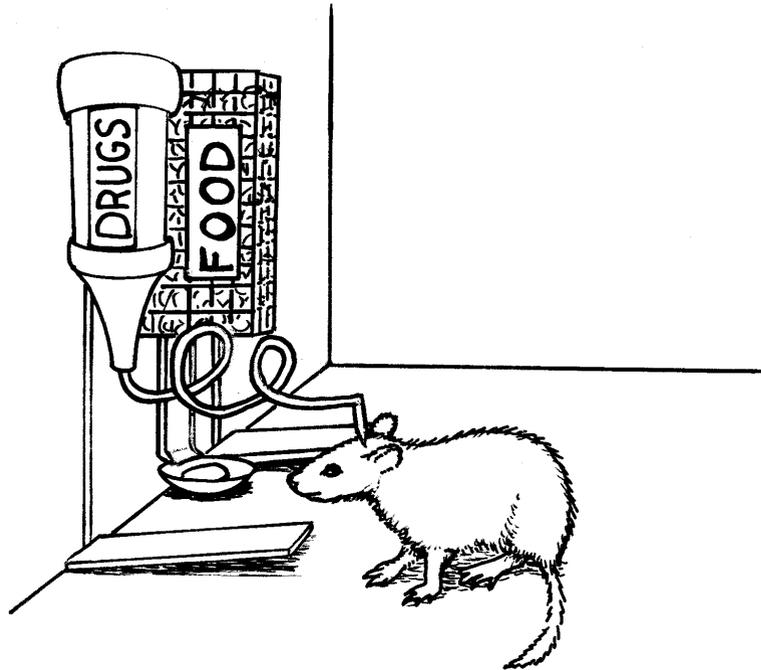


Data for Rat Self-administration Experiment

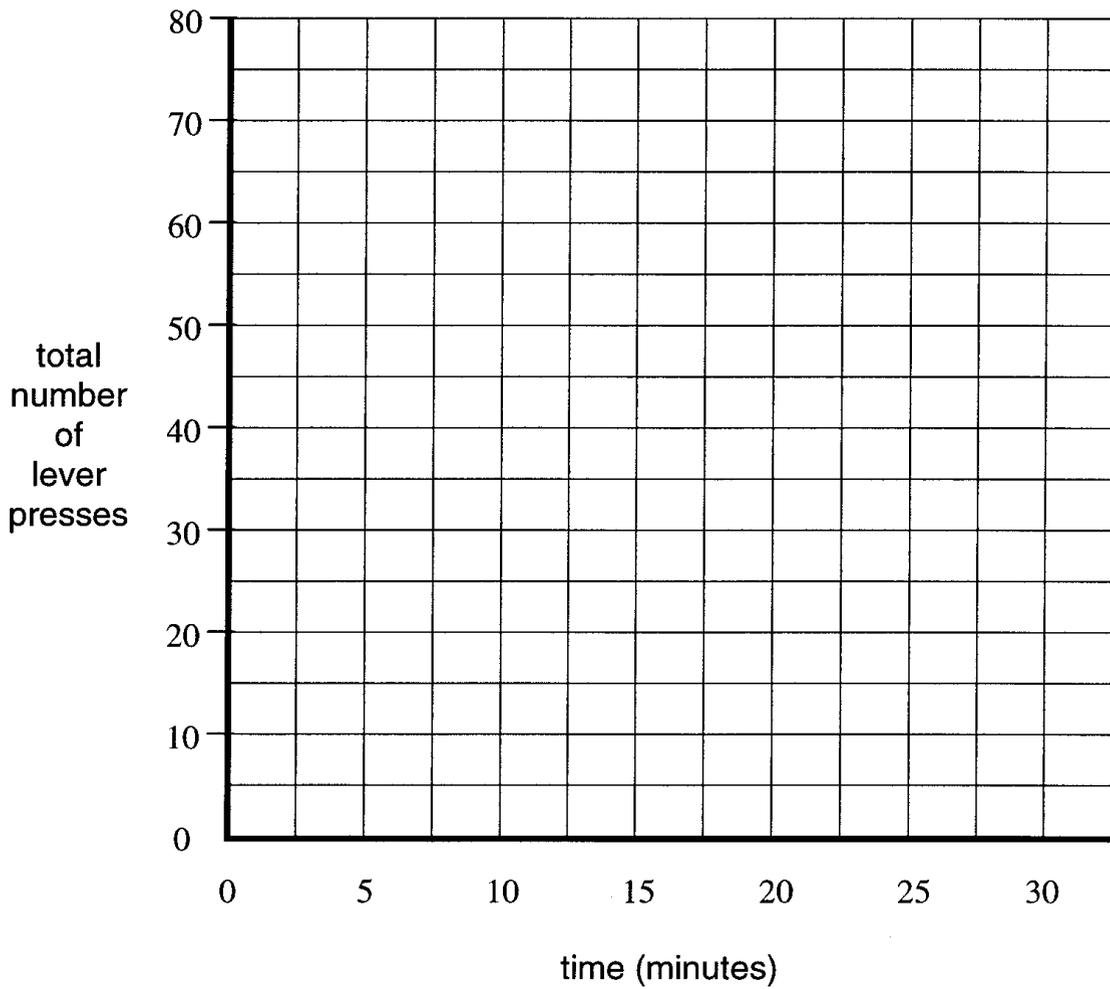


Total number of lever presses							
Rat	Lever	5 minutes	10 minutes	15 minutes	20 minutes	25 minutes	30 minutes
A	Stimulus	2	7	12	29	52	73
	Food	1	3	4	6	6	6
B	Stimulus	1	3	3	4	6	7
	Food	2	4	5	8	9	12
C	Stimulus	1	6	13	26	49	70
	Food	1	1	2	4	4	4
D	Stimulus	1	2	2	4	4	4
	Food	2	3	5	6	8	11

Worksheet for Rat Experiment Data

Plot the data for one of the rats in the experiment in the graph below. Plot the data for the stimulus lever using a colored pencil and the data for the food lever with another color.

Rat: _____



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Evaluating the Experiment

1. Why do the rats press a lever the first time?
2. Compare the lever-pressing behaviors of the four different rats. Which rat pressed the stimulus lever the most? Which one pressed the stimulus lever the least? Which rat pressed the food lever the most? Which one pressed the food lever the least?
3. Rat A was injected with cocaine each time it pressed the stimulus lever. Can you use this fact to explain why Rat A behaved the way it did?
4. Based on the data you analyzed, do you think Rat B was injected with cocaine when it pressed the stimulus lever? From what you have learned so far in this unit, do you think Rat B was injected with a different addictive drug when it pressed the stimulus lever? Why?
5. Do you think Rat C received cocaine when it pressed the stimulus lever? Why?
6. Rat C did not receive an injection of cocaine when it pressed the stimulus lever. When Rat C pressed the stimulus lever, it received a mild electrical stimulation in the brain. Based on what you have learned, can you predict what part of the brain was stimulated?

7. Rat D also received a mild electrical stimulation in the brain when it pressed the stimulus lever. Do you think the same part of the brain was stimulated in Rat D as was stimulated in Rat C? Why?

8. Why did Rats A and C press the stimulus lever more than the food lever?

9. Why did Rats B and D press the food lever more than the stimulus lever?

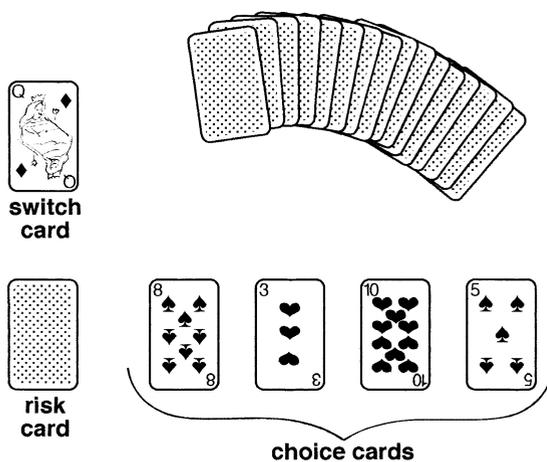
10. Why did the scientists who conducted this experiment include Rats B, C, and D in this experiment? How did the data from those rats help scientists understand more about how cocaine acts in the brain?

11. Do you think that Rats A and C will stop pressing the stimulus lever if they continue to receive the same stimulation each time they press it? Why?

12. Based on what you learned from these data, what might this investigation tell you about drug use by humans? Explain your view.

Playing the Game

1. Each person draws one card from the small pile of cards. Place it face up in front of you. This is your switch card. Set the rest of the cards in the short deck aside. You won't need them again.
 - If you drew a jack, your switch value is 25.
 - If you drew a queen, your switch value is 35.
 - If you drew a king, your switch value is 45.
2. Draw a card face down from the larger pile that contains aces and the number cards. **Don't look at this card.** Place it face down below your switch card. This is your risk card.
3. Draw cards from the large pile and place them face up next to the risk card. These are your choice cards. Draw as many choice cards as you wish, but keep in mind that you do not want the total of these cards plus the risk card to equal or go over your switch value.
 - An ace = 1 point
 - Other cards = the number on the card
4. When you have finished drawing cards, turn over the risk card. Did you match or go over your switch value?



Who Is Addicted?

Two people have been using morphine. Chris has been taking between 50 milligrams (mg) and 500 mg each day for a year. Pat has been taking 100 mg each day for six months. Only one of these individuals is addicted to morphine.

- Who do you think is addicted to morphine? Explain your answer.
-

Pat is addicted to morphine.

- Can you think of any reasons to explain why Pat is addicted even though Chris has been taking a much higher dose for a longer period of time?
-

Pat has been living on the streets for a year after losing a job. When the savings ran out, Pat couldn't afford the rent for an apartment any longer and couldn't afford to keep a car. Pat became really depressed. When another homeless person offered some morphine, Pat thought the drug might help make the problems of life go away. For the past six months, Pat and friends have been shooting up with morphine once each day.

Twelve months ago, Chris was in an accident and received third degree burns over 30 percent of the body. While in the hospital undergoing treatment, the pain was very intense. The doctors prescribed morphine that Chris could self-administer to control the pain. After all, morphine is one of the most effective pain-relief medicines available. At first, 50 mg of morphine each day would ease the pain. Later, however, Chris needed as much as 500 mg a day to ease the pain. Chris may need a dose of morphine 12 times each day.

Long-term Effects of Drugs on the Brain

So, why are drugs so bad? After all, the “high” or “rush” only lasts a little while, right? What else could be happening in the drug abuser’s brain? Consider that the brain is continuously changing. After all, learning occurs because neurons are forming new synapses. Scientists say that the brain has plasticity. That doesn’t mean the brain is made of a chemical plastic like a credit card, but it refers to the brain’s ability to modify connections in response to experience. When a person learns something or has new experiences, some new synapses may form or existing synapses may get stronger. Other synapses may disappear.

When a person takes drugs repeatedly, the brain changes in response to this experience. If a person takes drugs and then stops, he or she will “crave” the drug. In other words, the individual will have a strong desire to take more of the drug. Scientists can actually see evidence of cravings in the brain. If a cocaine addict sees pictures of drug paraphernalia, PET scans show that a part of the brain that is important for memory (called the amygdala) is activated. If the addict sees a video with mountains, trees, and animals, the amygdala is not stimulated. Thus, just seeing pictures of drugs or things associated with drugs can trigger an uncontrollable urge for drugs.

After taking drugs for a period of time, a person may need to take a higher dose of the drug to have the same rush that he or she did when first taking the drug. This is called tolerance. The brain has adapted to having a certain amount of drug present and does not respond the same way it did initially. That is why drug abusers and addicts take increasingly higher amounts of an abused drug. Tolerance may develop because the body may become more efficient at eliminating the chemical from the body, or because the cells of the body and brain become less responsive to the effect of the drug.

Scientific studies have shown clearly that certain drugs can cause dramatic changes in the brain, but not all questions have been answered. Drugs can change the structure of the brain. Perhaps one of the most dramatic long-term effects of a drug is to kill neurons. Many people have heard that drinking alcohol will kill brain cells. It’s true. If alcohol is abused over a period of time, neurons in the brain can die. Some neurons in the brain are more sensitive to alcohol than others. Neurons that make up the mammillary bodies, areas in the brain that are important for memory, are more vulnerable to the effects of alcohol than are some other neurons in the brain. The neurons in the cerebral cortex, the part of the brain that controls most of our mental functions and endows us with consciousness, may also die if a person frequently abuses alcohol in high doses.

Another drug that is toxic to neurons is an amphetamine derivative called MDMA, or ecstasy. In rats and non-human primates, MDMA appears to kill neurons that produce serotonin, a neurotransmitter that is involved in regulating appetite, sleep, emotions, and so on. In some parts of the brain, the axons of some of these neurons may regenerate (or re-grow) after drug use is stopped, but the new growth of the neurons is not normal. Some areas are not reinnervated (nerve fibers do not grow back into the area) as they were before the drug abuse and

some areas have abnormally high regrowth of the neurons. Either way, the neurons are not normal. Studies have not yet been able to determine if MDMA has this same effect on humans, but some preliminary evidence indicates that MDMA may kill serotonin neurons in humans.

Cocaine also changes the brain in ways that may last for a long period of time. PET scans of human brains have shown that glucose metabolism is reduced even three months after the last use of cocaine. Remember that glucose metabolism is an indicator of how active the brain cells are. If the neurons are using less glucose, they are not as active. The changes that cocaine causes in the brain last much longer than the pleasurable feelings it produces. Other drugs cause similar decreases in brain activity. Even two years after the last use of amphetamines, PET images show that the drug abuser's brain is less active than the person's who never used drugs.

Scientists, for many reasons, don't know all of the effects that a drug may have. First, the brain is such a complicated organ that, despite great scientific advances, understanding all that it does will take many more years. Second, individuals may respond differently to drugs due to genetic differences among people. Third, many drug abusers abuse more than one drug. Many individuals who take cocaine, for example, also drink alcohol. The combination of the drugs makes it difficult to determine what the effect of one drug alone may be. Another complication is that drug addicts may have other health problems in addition to their drug problem. Heroin addicts, for example, spend most of their energy and activity trying to get their next "fix." Consequently, they do not eat well and may have impaired immune systems. Also, drug addicts often suffer from mental illnesses, such as depression. The changes that occur in the brain because of mental illness make it difficult to determine what changes the drugs have caused.

The brain is an incredibly complex organ. This complexity will keep scientists working for many years to understand how the brain works. Someday, scientists will answer questions about what happens in the brain to cause addiction, which will then help scientists understand how to prevent addiction.

1. What are some of the ways that drugs cause long-term changes in the brain?
2. How does the brain adapt to the presence of drugs?
3. How may the abuse of drugs relate to the plasticity of the brain?
4. What are some problems that scientists have when they investigate the effects of drugs on the brain?